Towards More Reliable Energy Measurements

Scaling Characteristics of M> 5.8 earthquakes

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Introduction

- Seismic energy can be estimated using different techniques and different types of data
- In the past:
  - ➔ Each of them gave a different value of E_s for the same event
  - ➔ Questions on the corrections applied
- Important that before a definite conclusion is drawn, we get consistent and more reliable estimates of seismic energy

Introduction

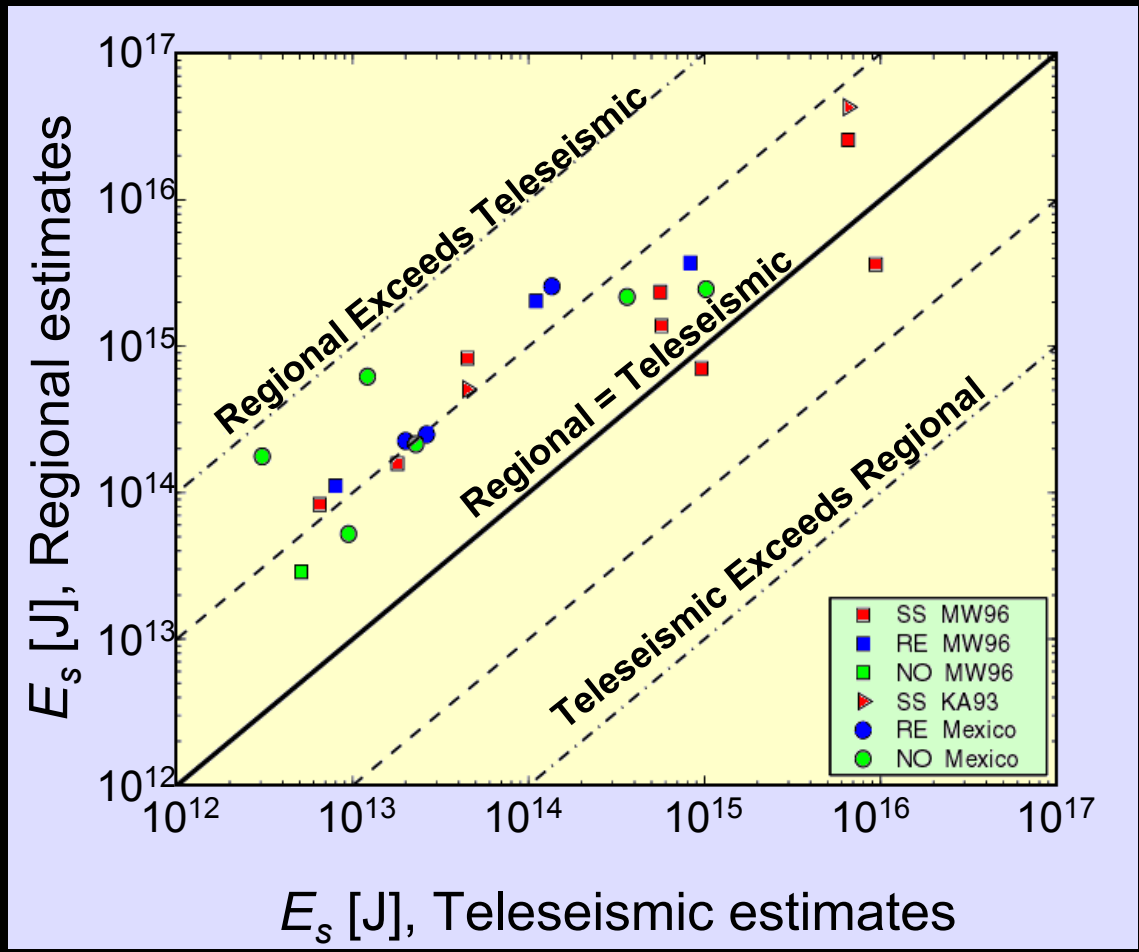
- Now:
  - ➔ We are able to get more consistent and reliable values of E_s
    - We include some corrections, overlooked or simplified before
    - We improve the teleseismic estimation by using a weighting technique that takes into account the uncertainty in the parameters and corrections

Teleseismic vs Regional

- Regional estimates larger than teleseismic

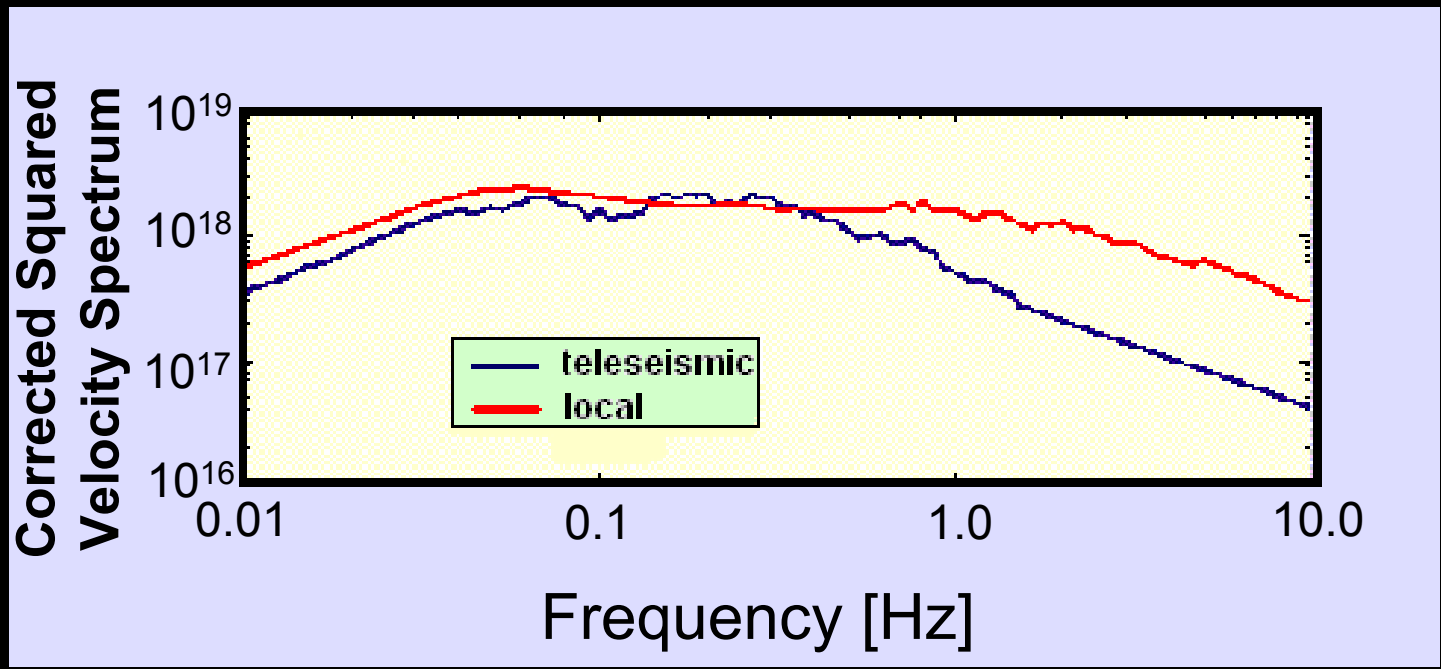
Singh and Ordaz [1994]
Mayeda and Walter [1996]

- Up to one order of magnitude difference
- Difference independent of focal mechanism



How do we reconcile these estimates?

- Fundamental measure is the integral of squared velocity spectrum

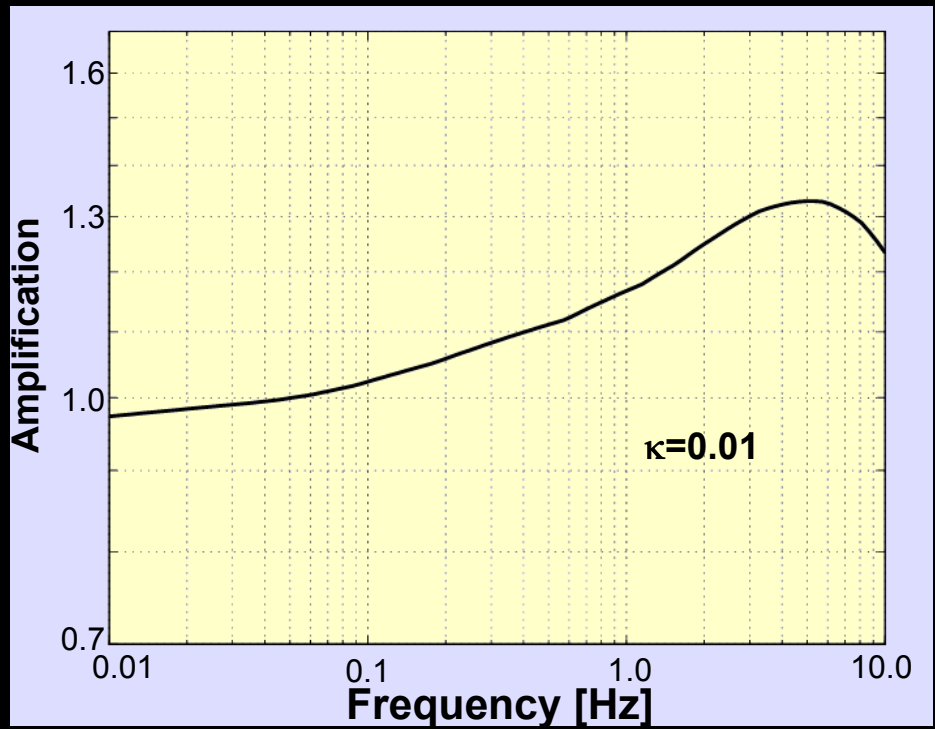


- In general, larger differences at high frequencies

Site Effect

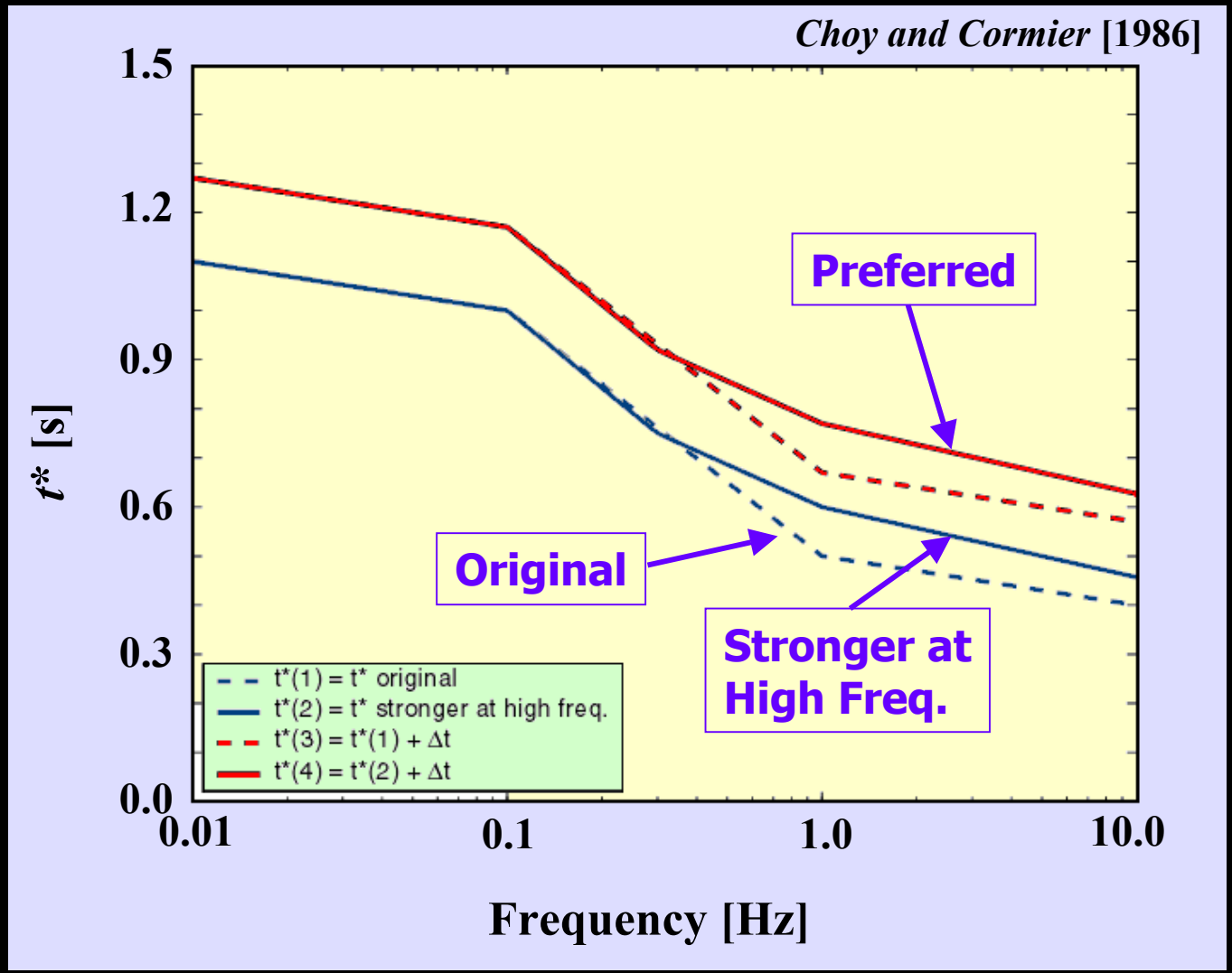
- Correction for combined effect due to amplification and attenuation produced by a rock at the station [*Boore and Joyner*, 1997]
- Need to know the velocity model at the station

  Boatwright et al. [2002]:
- Regional: Generic-rock model
- Teleseismic: Hard-rock model



- Lack of site correction can produce overestimation of E_s

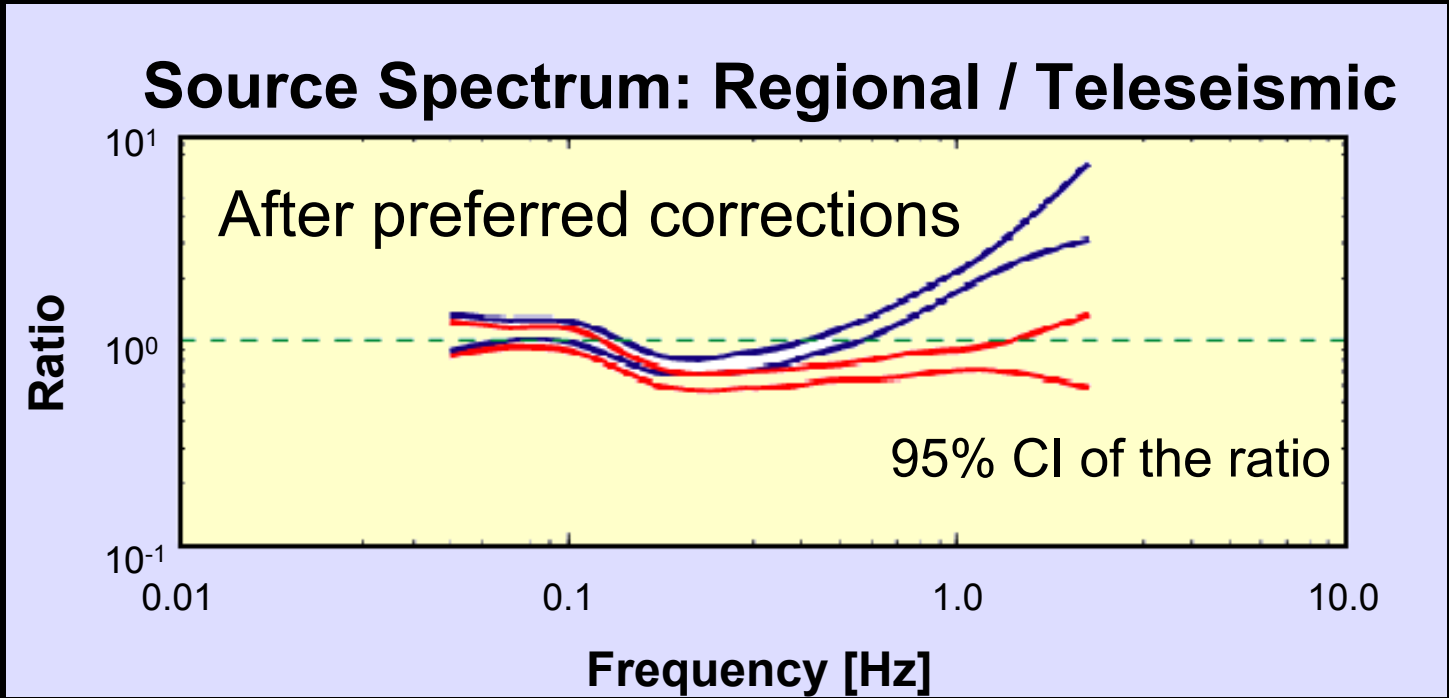
Teleseismic Attenuation



Regional Attenuation and Geometrical Spreading

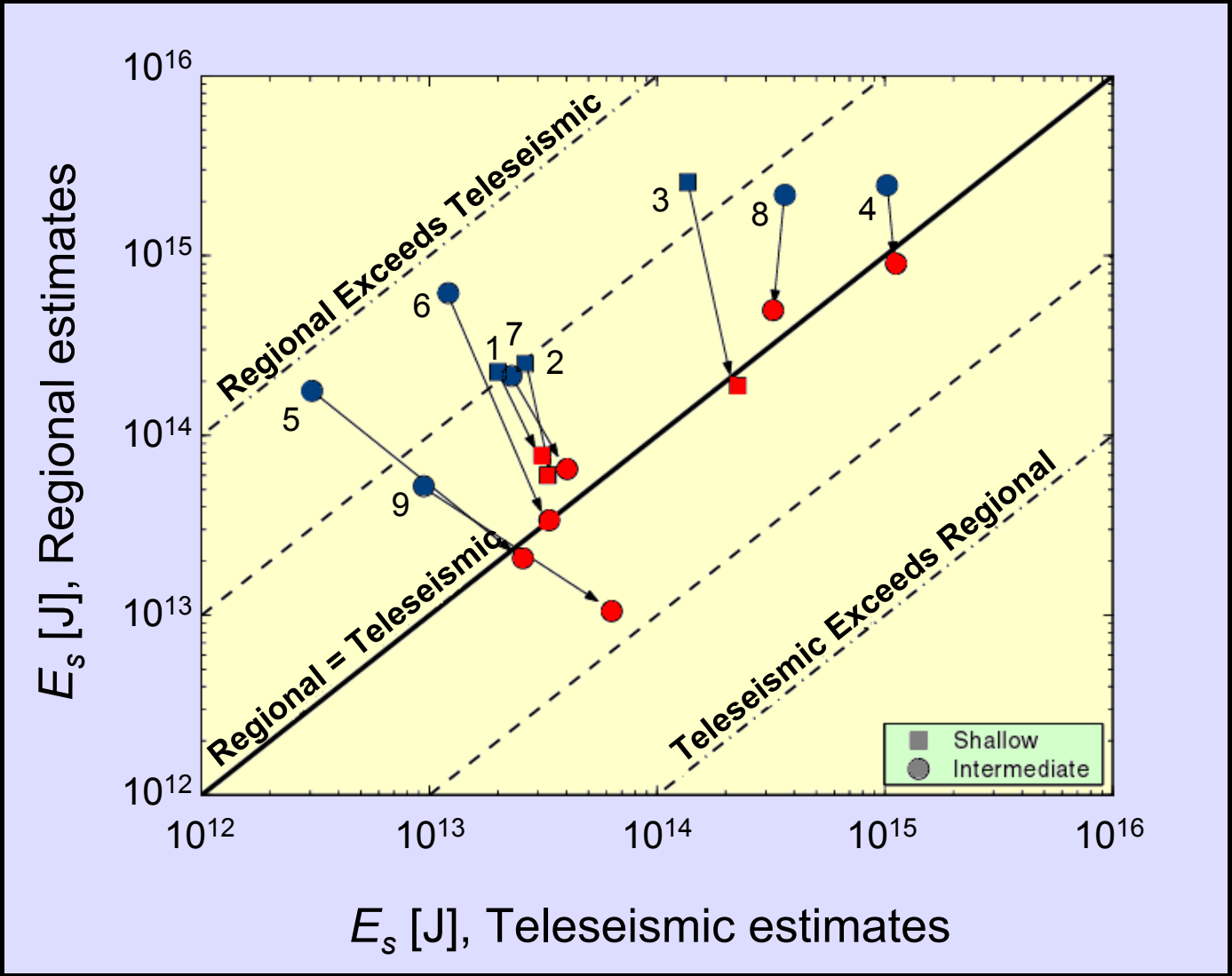
- Use of regional attenuation models previously obtained by other authors
  - ➔ Shallow earthquakes [*Ordaz and Singh*, 1992]
    - Similar trajectories
  - ➔ Intermediate earthquakes [*García Jiménez*, 2001]
    - Same events and stations
- Regional attenuation was modeled assuming a frequency independent geometrical spreading
- No systematic behavior of residuals with distance

Preferred Corrections: Site Effect & Attenuation

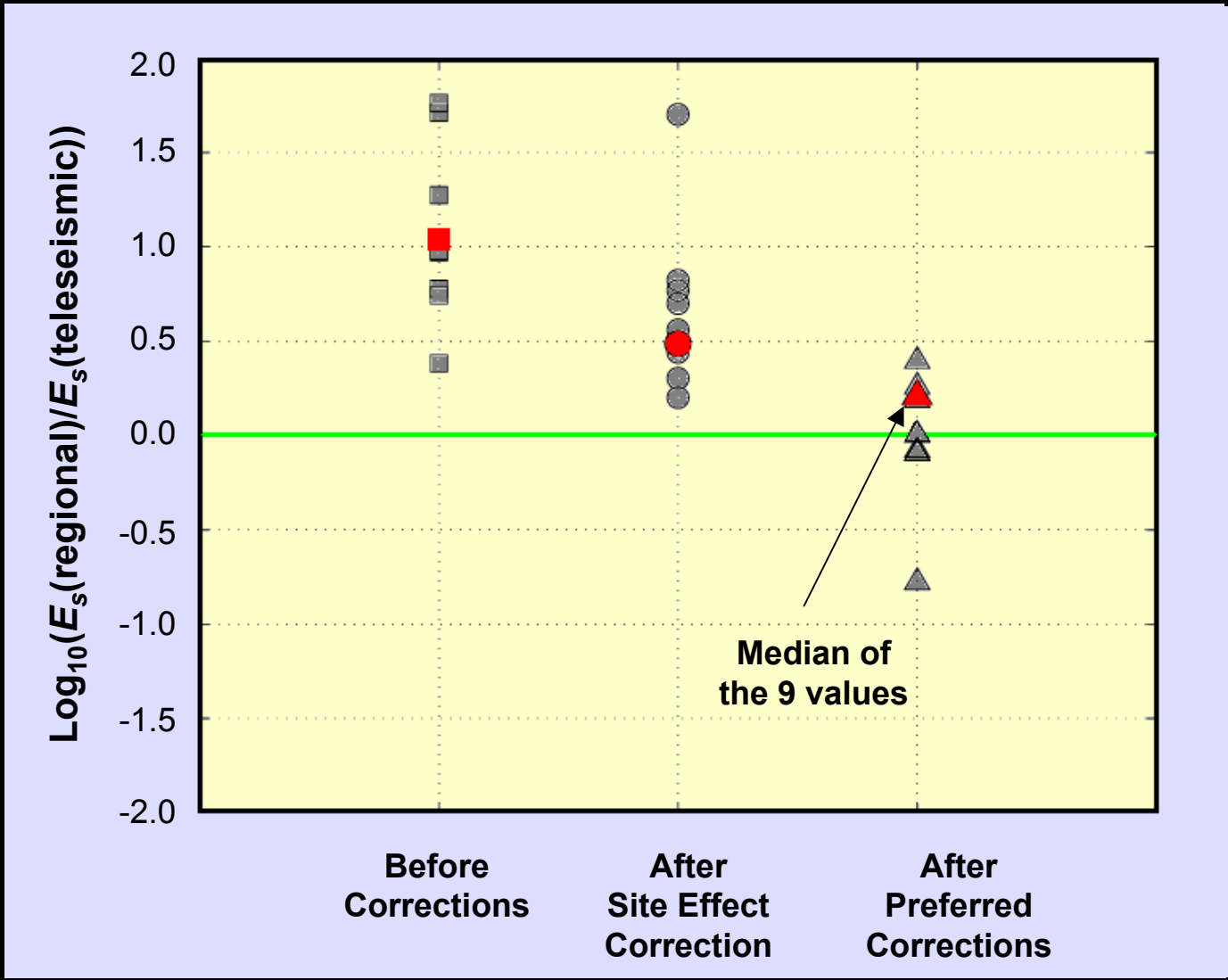


- Using a site effect correction and modified teleseismic attenuation model, the spectra become closer to each other

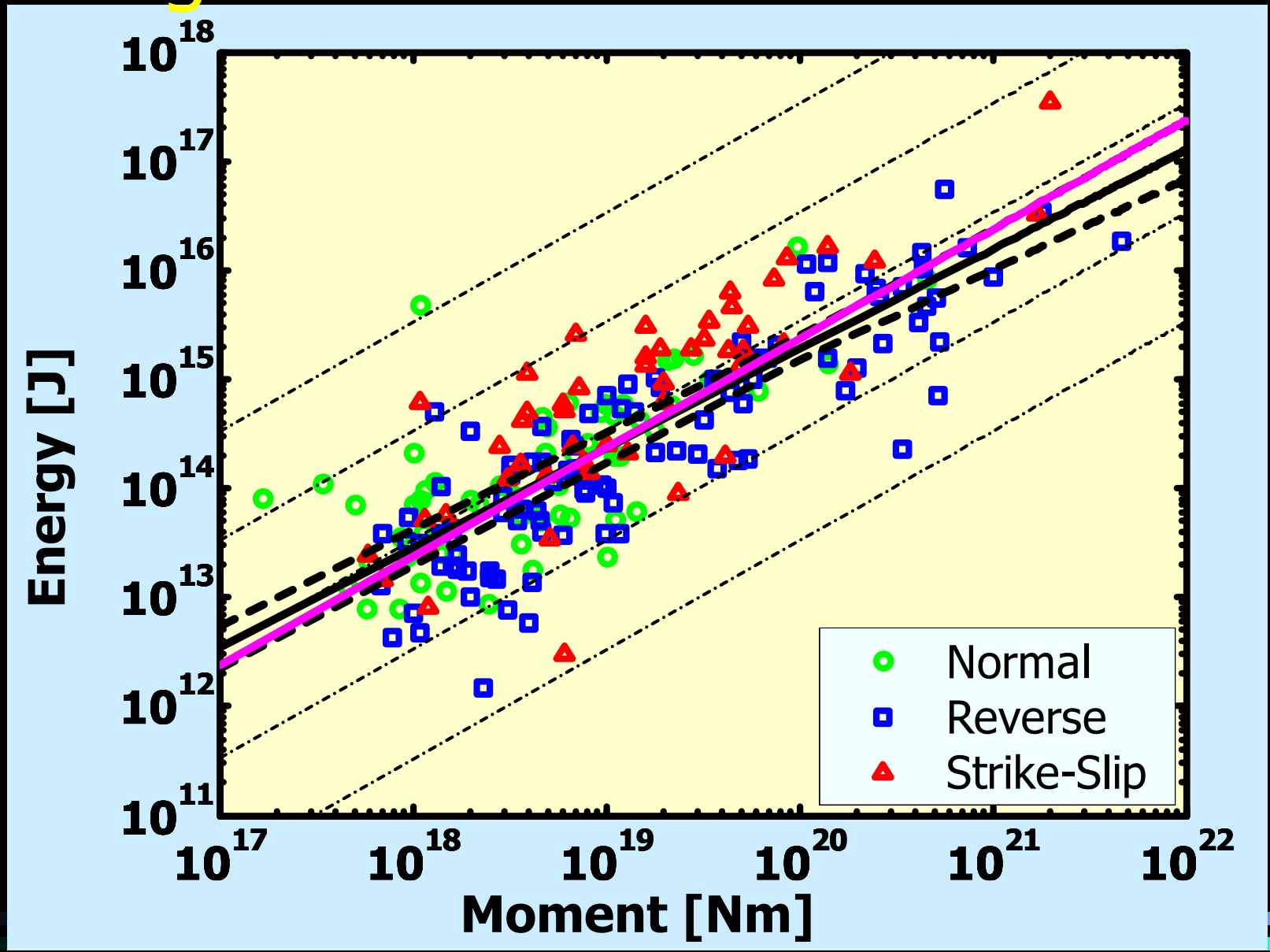
Discrepancy Reduced



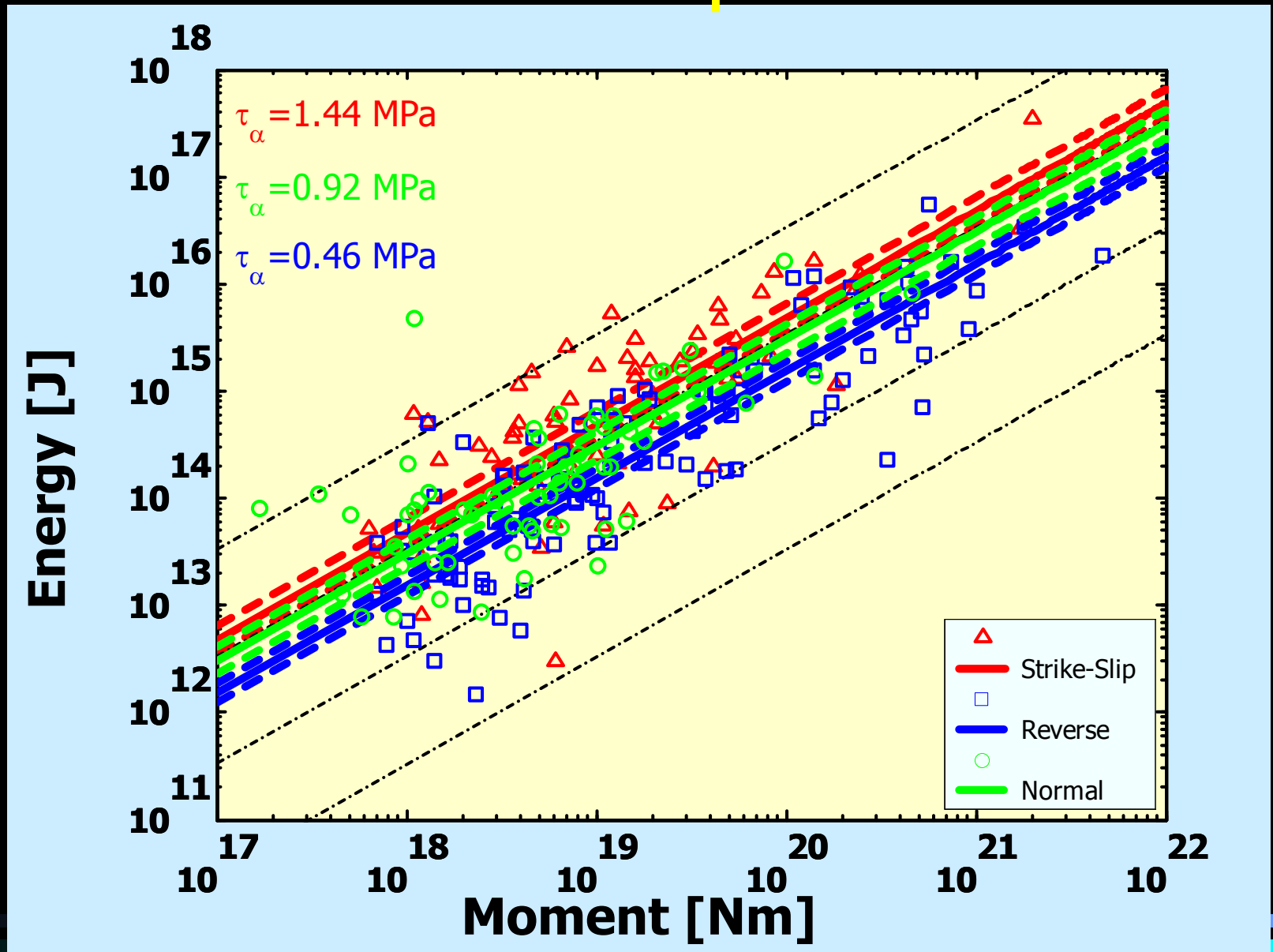
Measure of Discrepancy



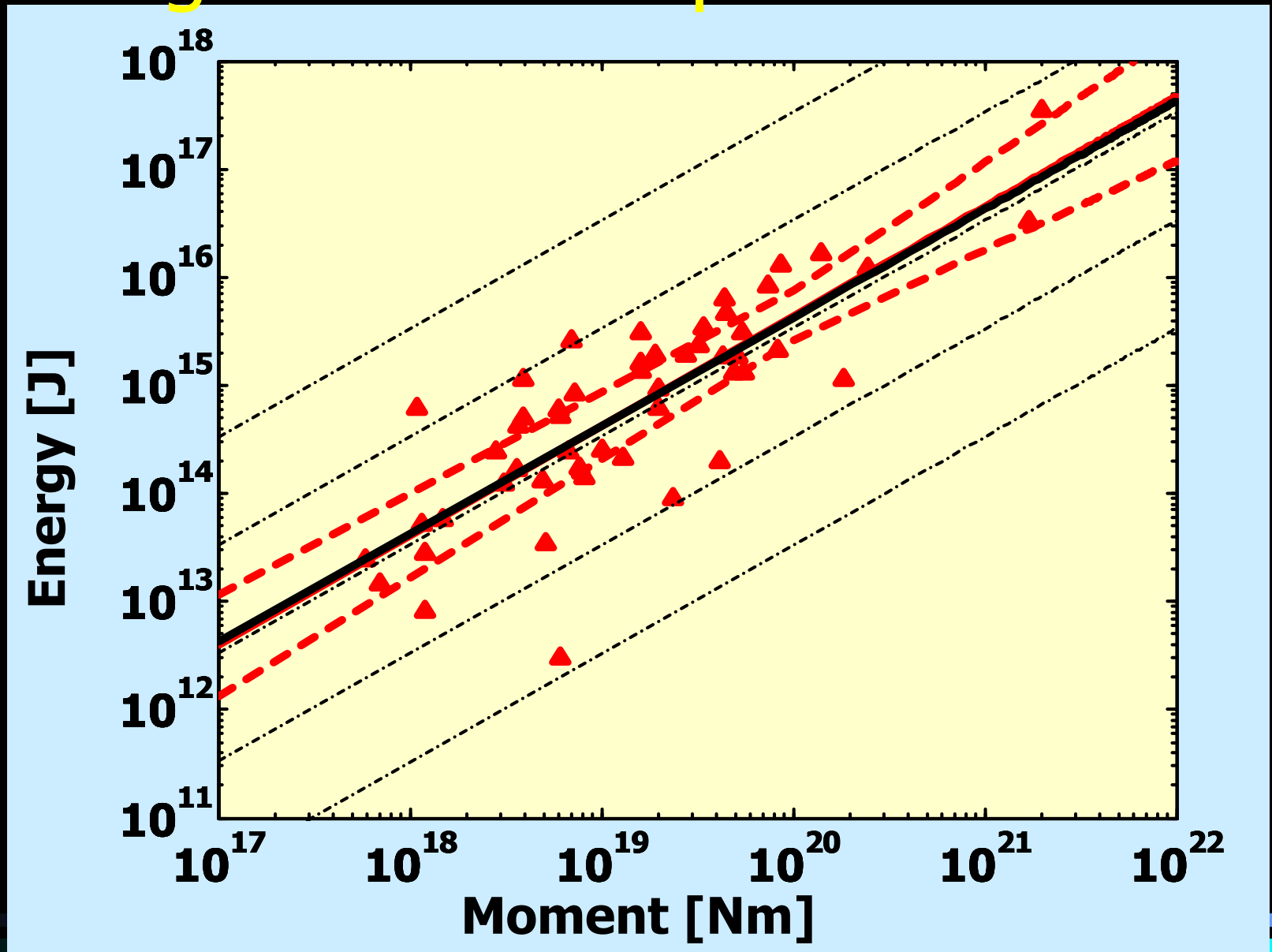
Scaling


Energy [J]
10^{18}
10^{17}
10^{16}
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
10^{17}
10^{18}
10^{19}
10^{20}
10^{21}
10^{22}
Moment [Nm]
Normal
Reverse
Strike-Slip

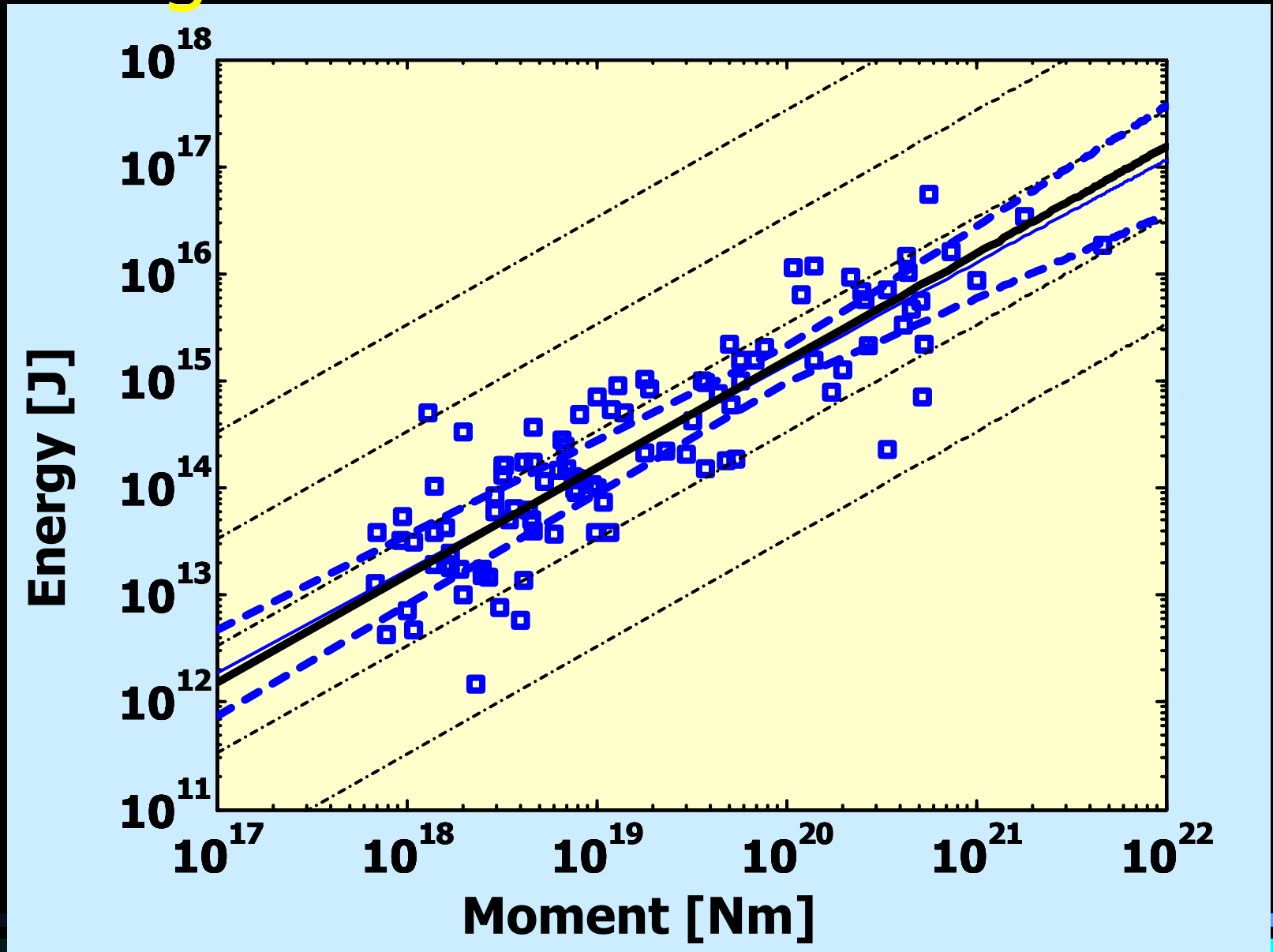
Focal Mechanism Dependence



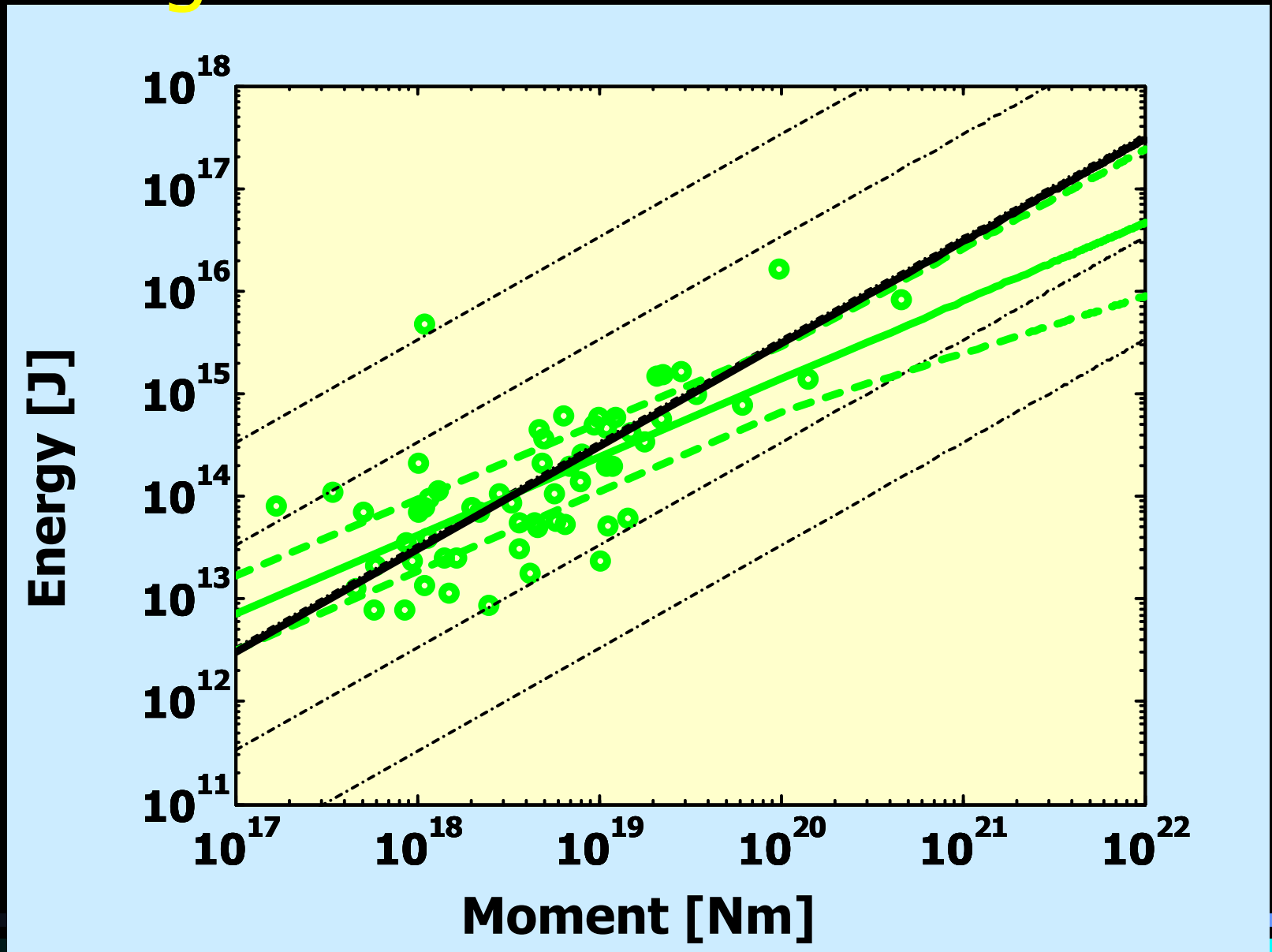
Scaling for Strike-Slip



Scaling for Reverse



Scaling for Normal



Conclusions

- Uncertainties in the estimation of E_s can be included, which give us a better knowledge of the uncertainty when estimating it
- More reliable and consistent values of E_s are now estimated
- When analyzing M>5.8 earthquakes, there is no statistical significant scaling of E_s with M_0

How Significant?

- Statistically significant?
- Physically significant?
- Enough data?
- Enough information?